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ROLE OF DOUBLE-POROSITY DUAL-PERMEABILITY MODELS FOR MULTI-RESONANCE GEOMECHANICAL SYSTEMS

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ABSTRACT

It is known that Biot's equations of poroelasticity (Biot 1956; 1962) follow from a scale-up of the microscale equations of elasticity coupled to the Navier-Stokes equations for fluid flow (Burridge and Keller, 1981). Laboratory measurements by Plona (1980) have shown that Biot's equations indeed hold for simple systems (Berryman, 1980), but heterogeneous systems can have quite different behavior (Berryman, 1988). So the question arises whether there is one level --- or perhaps many levels --- of scale-up needed to arrive at equations valid for the reservoir scale? And if so, do these equations take the form of Biot's equations or some other form? We will discuss these issues and show that the double-porosity dual-permeability equations (Berryman and Wang, 1995; Berryman and Pride, 2002; Pride and Berryman, 2003a,b; Pride et al., 2004) play a special role in the scale-up to equations describing multi-resonance reservoir behavior, for fluid pumping and geomechanics, as well as seismic wave propagation.

The reason for the special significance of double-porosity models is that a multi-resonance system can never be adequately modeled using a single resonance model, but can often be modeled with reasonable accuracy using a two-resonance model. Although ideally one would prefer to model multi-resonance systems using the correct numbers, locations, widths, and amplitudes of the resonances, data are often inadequate to resolve all these pertinent model parameters in this complex inversion task. When this is so, the double-porosity model is most useful as it permits us to capture the highest and lowest detectable resonances of the system and then to interpolate through the middle range of frequencies.

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